NEURO-VESTIBULAR EXAMINATION DURING AND AFTER SPACEFLIGHT (VESTIBULAR HEALTH)

CIPHER: Complement of Integrated Protocols for Human Exploration Research

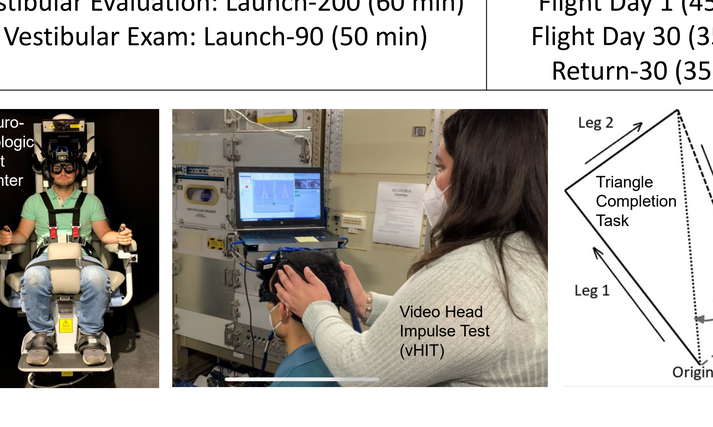
TR Macaulay[1*], SJ Wood[2], MF Reschke[2], Y De Dios[1], JP Dervay[2], T Makishima[3], MC Schubert[4], M Shelhamer[4], GR Clément[1]

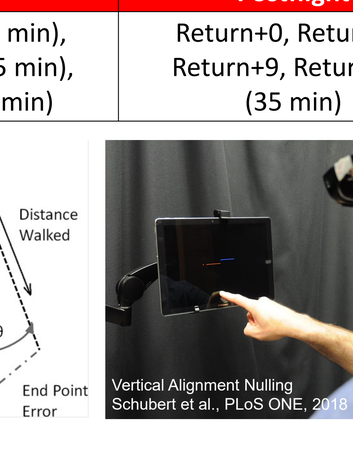
[1]KBR, Houston, TX, [2]NASA Johnson Space Center, Houston, TX, [3]UTMB Health, League City, TX, [4]Johns Hopkins University School of Medicine, Baltimore, MD

*Contact: timothy.r.macaulay@nasa.gov

BACKGROUND

- Adaptation to microgravity causes neurological disturbances that are mediated by the vestibular system:
  - ➢ Space motion sickness, spatial disorientation, and cognitive impairment, as well as changes in head-eye coordination, vestibulo-ocular reflexes, and control of posture and locomotion.
- Otolith-mediated reflex gains appear to adapt rapidly to g-transitions, but animal studies suggest that there are long-term structural modifications to the vestibular apparatus.
- What are the severity and mechanisms of symptoms as a function of spaceflight duration?





OBJECTIVES

- Use well-established clinical and experimental procedures to:
  - ➢ Identify temporal trends in adaptation of vestibular health and performance.
  - ➢ Differentiate between peripheral and central vestibular forms of vertigo and oculomotor disorders.

Trade names and trademarks are used in this report for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

METHODS

- Data collection:
  - ➢ Eye, head, and body movements, as well as subjective reports of perception of motion.
- To determine the presence of:
  - ➢ Abnormal eye movements, dysmetria, motion sickness symptoms, and illusions of motion.
- Characterization of temporal trends in central compensation for vestibular (otolith) asymmetry.

Testing Schedule for standard (6-month) flights:

Preflight	Inflight	Postflight
Vestibular Evaluation: Launch-200 (60 min) Vestibular Exam: Launch-90 (50 min)	Flight Day 1 (45 min), Flight Day 30 (35 min), Return-30 (35 min)	Return+0, Return+4, Return+9, Return+30 (35 min)

GROUND CONTROL RESULTS

- Healthy (non-astronaut) control subjects performed the same ground test procedures as planned for crewmembers (n = 32) to establish a normative database.
- These data were also used to calculate vestibular asymmetries from perceptual reports during unilateral centrifugation, oculomotor responses during visual-alignment tasks, vestibulo-ocular reflex gain during head-impulse tests, and body rotation during stepping tests.

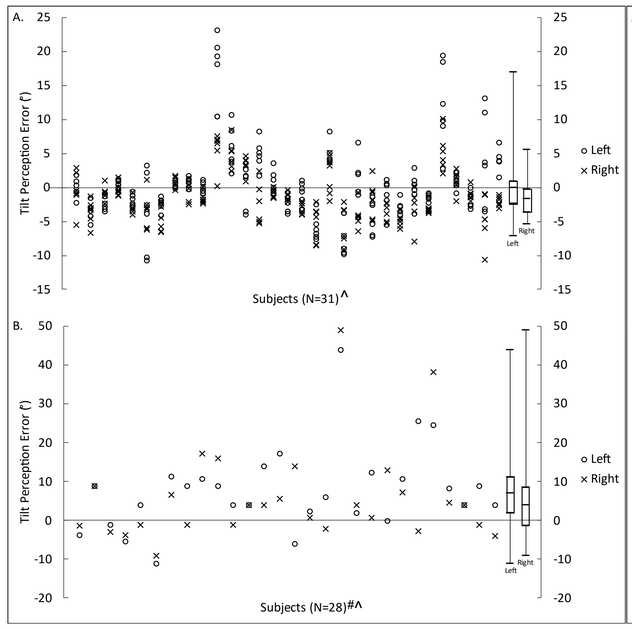


Figure 1. Error in tilt perception relative to the gravito-inertial acceleration measured by the Subjective Visual Vertical (A) and Verbal Response (B) during unilateral centrifugation to the left and to the right. #data from one subject excluded (misunderstood instructions) ^data from three subjects not collected

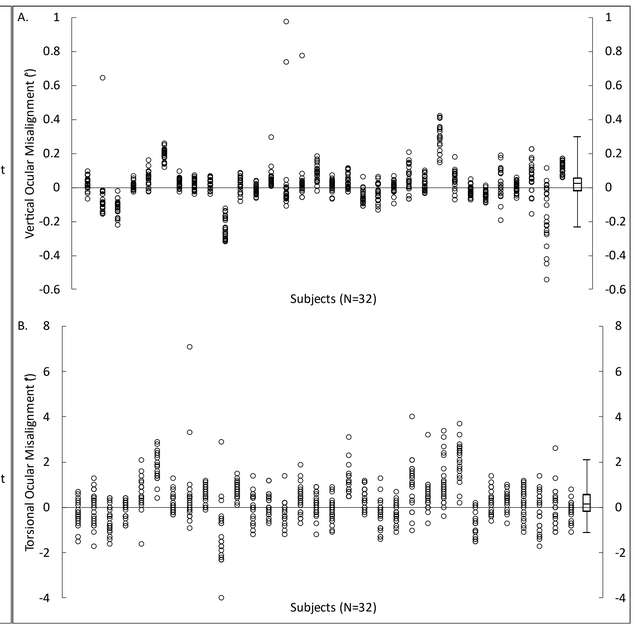


Figure 2. Ocular misalignment obtained from vertical alignment nulling (A) and torsional alignment nulling (B) trial.

- A significant correlation was observed between asymmetries of subjective visual vertical and verbal report during unilateral centrifugation. Another significant correlation was observed between the asymmetries of ocular alignment, vestibulo-ocular reflex gain, and body rotation.

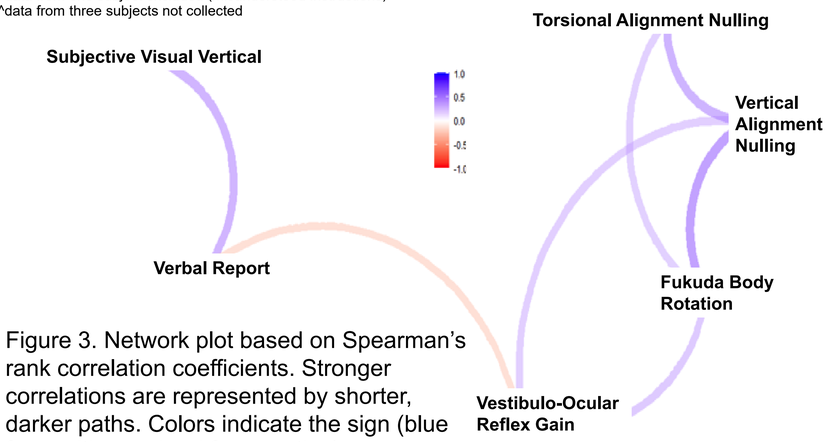


Figure 3. Network plot based on Spearman's rank correlation coefficients. Stronger correlations are represented by shorter, darker paths. Colors indicate the sign (blue for positive and red for negative).

- Strong correlations suggest that various tests measure the same underlying vestibular asymmetry within healthy participants. In contrast, weak correlations indicate that the perceptual tests might be measuring different aspects of asymmetry than the ocular/postural tests.
- These findings may help us understand how changes in vestibular asymmetries manifest across tests in crewmembers after exposures to g-transitions.

RELEVANCE

- The flight data will help us characterize temporal changes, determine when countermeasures may be needed, and understand the etiology of vestibular syndromes.
- Countermeasures will be proposed based on vestibular rehabilitation currently used in patients with vestibular disorders.

ACKNOWLEDGEMENT: This work is supported by NASA's Human Research Program Human Health Countermeasures Element and Research Operations & Integration